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Diseases, Insects, Pests

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Electric Fences for Protecting Livestock from Predation

Electric fences have been used to protect livestock from predators in Alberta for nearly two decades. An evaluation of electric fences by Alberta Agriculture in the mid 1970s showed that a 90 per cent reduction in predation occurred on sheep farms with a history of coyote problems when electrified fencing was used. Several studies conducted since then have confirmed these results. Electric fences have proven to be an effective non-lethal method of preventing predation. Electric fences are easily adapted to most livestock operations, relatively easy to maintain and cheaper to build than conventional page and barb wire fences. However, electric fences require routine inspection and maintenance to reach full protection capabilities.

Design

The nine- ice is the most economical design to build when a new fence is required or when existing fences must be replaced. An electric fence of nine high-tensile smooth steel wires (12.5 gauge) alternating charged and grounded provides an effective barrier to predators (figure 1). All electrically charged wires require insulators to ensure maximum shocking power. Connect all common wires in parallel at 0.5 km intervals along the entire length of the fence. Connect all grounded wires to ground rods at 0.5 km intervals along the fence. Ground rods, 1-2 m in length, should be driven into the soil, preferably in moist areas.

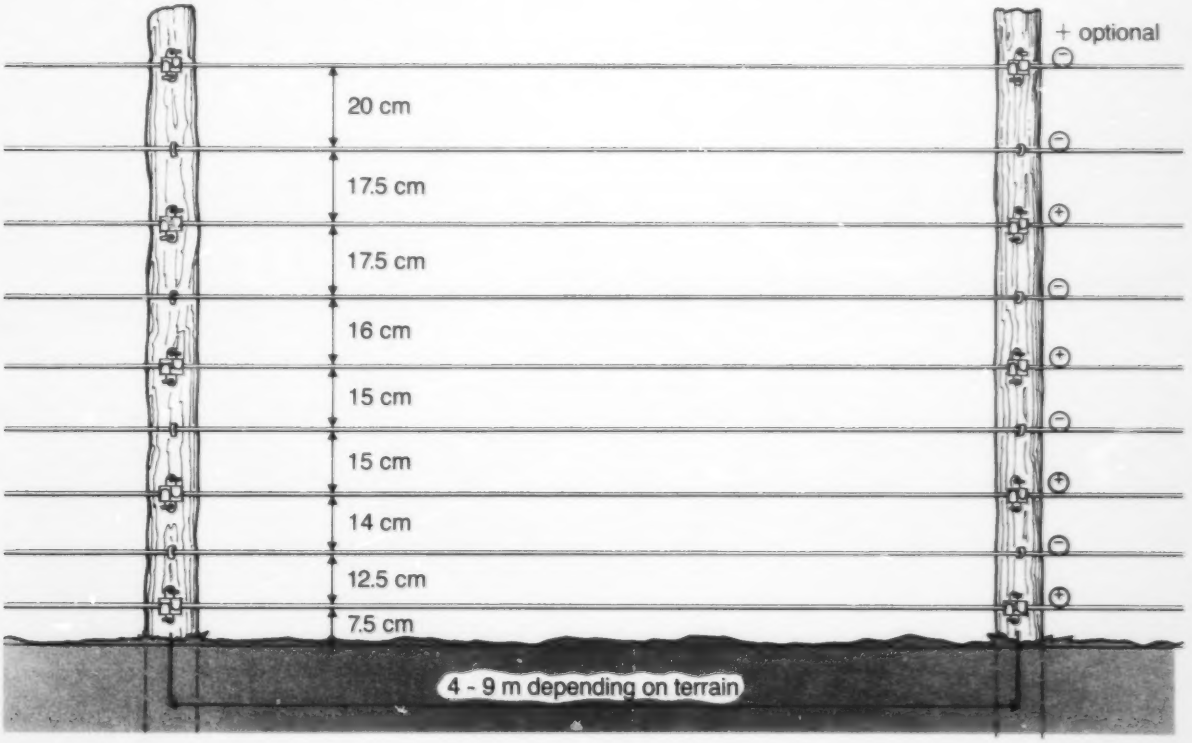

Figure 1. Nine-wire predator fence, viewed from inside of pasture.

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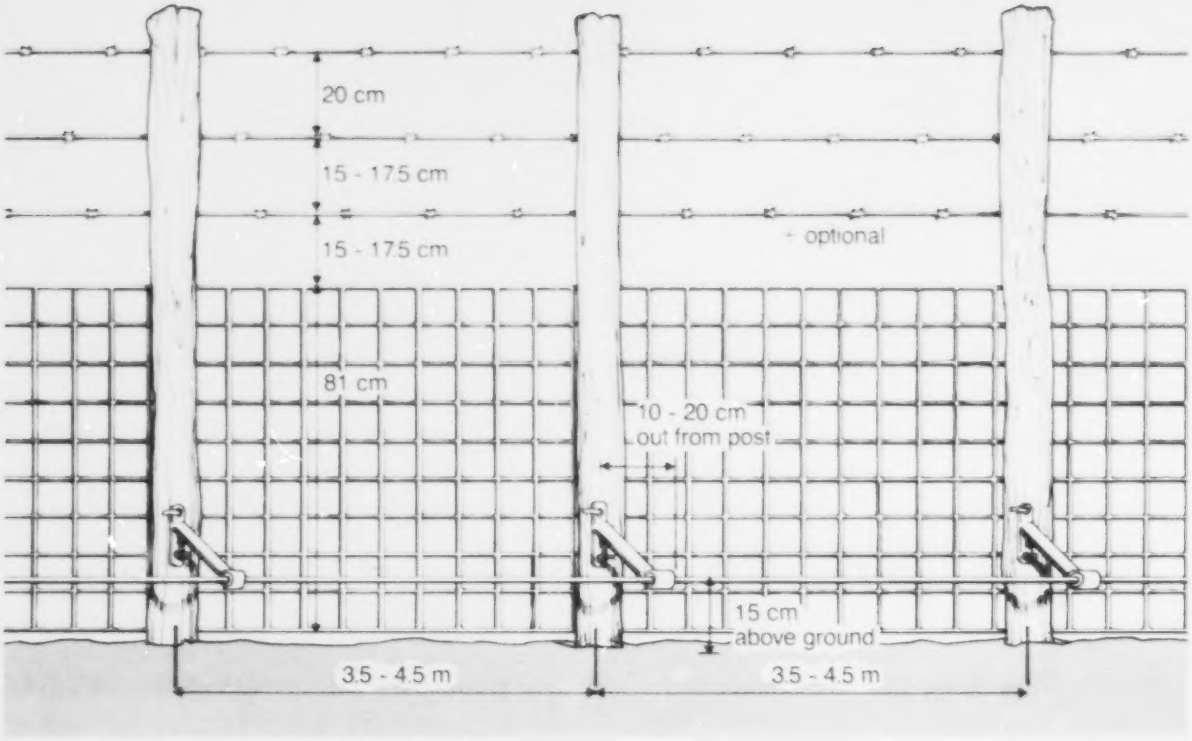


Figure 2. Electrified conventional sheep fence, viewed from outside of pasture.

A conventional sheep fence of two strands of barbed wire 15-17.5 cm apart, above a woven wire fence 81 cm high, can be modified quite easily (figure 2). However, it is essential that the wire which will be energized is free from rust and that the fence is in good condition. On the outside of the fence place a charged 12.5-gauge smooth wire 15 cm from the ground and 10-20 cm out from the fence . If the posts are 10 cm or more in diameter and on the outside of the woven wire, insulators and the charged wire can be attached directly to the outside of the posts. For smaller posts, offset brackets will be necessary. Offset brackets are commercially available or can be manufactured from lumber. This modification will discourage coyotes from digging under the fence. Place an additional wire 20 cm above the top fence wire to discourage coyotes from jumping over the fence. It may not be necessary to electrify more than the bottom outside wire. Electrify the lower outside wire first. If predation occurs, electrify the first wire above the woven wire.

Coyotes will normally dig under or go through a fence rather than jump over a fence that is of adequate height. The ideal height for a fence seems to be 1.37 m (4 1/2 ft). Construction costs increase dramatically for fences taller than 1.37 m. The minimum acceptable height for a fence is 1.22 m (4 ft); coyotes are likely to jump fences shorter than 1.22 m. If the posts are less than 1.22 m in height, additional, taller posts will have to be placed in the fenceline or post height will have to be extended with brackets.

If cattle or horses are pastured on either side of the fence, electrify the first wire above the mesh wire so that livestock do not stick their heads through the fence and push down the mesh wire. Keep all electrified wires taut. Several types of wire tighteners are commercially available which can be permanently attached to each wire. Ensure that the woven wire is free of holes to prevent coyotes or dogs from crawling through the mesh. Do not use a mesh wire size larger than 15 cm.

Electric fence operation

For electricity to flow in a system such as an electric fence, there must be a complete and uninterrupted circuit. This means that the electrical current must travel from its electrical source (fence energizer), through the circuit (fence) and return to the source. When the fence energizer is turned on, the circuit is referred to as open because the circuit is incomplete. The electrical circuit is completed when an animal touchs a charged wire and a grounded wire; the circuit is referred to as closed and the animal receives a shock. Accumulated litter or vegetation under the fence or a fallen tree on a charged wire will also close the circuit. Litter and debris may totally drain the available current and make the fence ineffective.

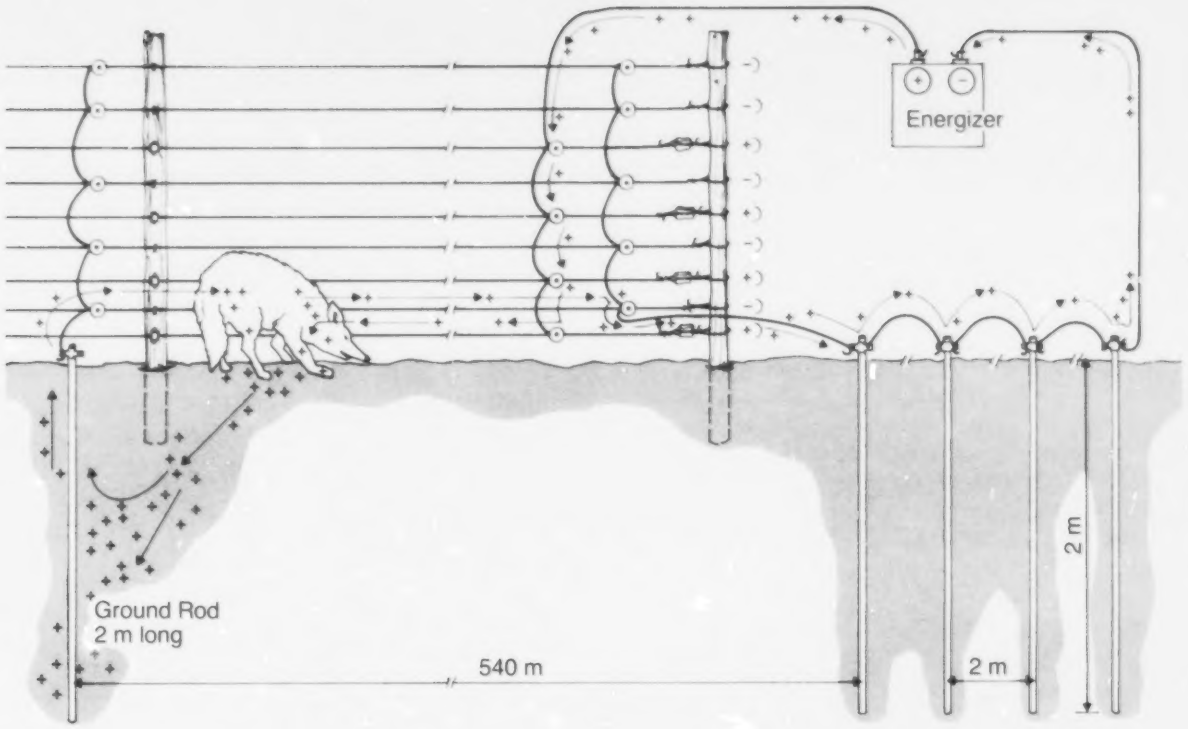


Figure 3. Current flow when a coyote touches an electric fence. Note the configuration of the ground rods and wires.

A shock from an electric fence with alternating charged and grounded wires can be delivered in either of the following ways (figure 3):

a) A coyote will receive the maximum shock when it touches a charged wire and a grounded wire simultaneously. In this case, electricity travels from the energizer through the charged wire, through the coyote into the grounded wire, and back to the energizer. The conductivity (ease with which electricity travels through a circuit) through the system, including the coyote, will be very high. This forms the basis for recommending alternating charged and grounded wires.

b) When a coyote contacts only a charged wire, electricity passes through the coyote, goes into the soil to the nearest ground rod, and then through the ground rod and wire to the energizer. Conductivity through soil is poor as compared to wire; therefore, the intensity of the shock a coyote receives will be inversely related to the distance between it and the nearest ground rod. This emphasizes the importance of ground rods at regular intervals along the fence. The effectiveness of this system is also dependent on soil type and soil moisture.

Fence line selection and preparation

When planning the fence, give serious thought to the location and condition of the fenceline. Try to select the most even ground to run the fence and refrain from crossing sloughs, creeks, ravines and other obstacles. If possible, fence out these and other undesirable areas from the pasture. Keep your fenceline as straight as possible.

Prepare the fenceline by removing trees, shrubs and other vegetation and then level the fenceline area. Leave sufficient room along the fenceline to drive a pickup or tractor at a later date for inspection and maintenance. Disc the fenceline to smooth the surface; remove low spots where coyotes might crawl under a fence and high spots that can ground the bottom wire. Then reseed the fenceline with a low-growing vegetation which will minimize grounding. Final preparation can involve application of a soil sterilant to prevent regrowth of vegetation beneath the fenceline.

Fence energizers

Electric fence energizers have changed dramatically during the last 15 years. Improved technology has caused a flood of high-energy fence energizers, improved insulating materials and alternative sources of electrical power to appear on the market.

There are two types of energizers currently available: uni-polar and bi-polar. The most common type is the uni-polar which has a positive (+) terminal and a negative (-) ground terminal. It may also have a choice of high, medium or low output voltages. Uni-polar energizers are normally used with alternating charged and grounded wires.

The bi-polar energizer has both positive (+) and negative (-) charged terminals connected to alternate wires on a fence as well as a ground terminal that is connected to a ground rod. This results in only half the voltage of the energizer between any wire and the ground, yet the full guard voltage exists between oppositely charged wires. For example, a bi-polar energizer of 5000 volt output when connected to a fence will produce 2500 volts equally to positively charged and negatively charged wires. If the circuit is closed by an animal touching only one wire, the electricity will flow through the animal and through the ground and the animal will receive 2500 volts; if it touches both positive and negative wires simultaneously, it will receive 5000 volts. Bi-polar energizers require insulators on both grounded and charged wires. However, the advantages of bi-polar energizers are that:

1) all the wires are "hot", and
2) there tends to be less energy loss with a bi-polar energizer when fences are grounded by grass, leaves and other debris. This feature can provide higher guard voltage under poor conditions and acceptable power to a longer than normal fence.

Consider the following factors when selecting an energizer:

- gauge, type and total length of wire to be electrified
- availability of mainline power
- rated and actual outputs of various energizers
- initial and operating costs of various units

Units best suited for predator control are high energy solid state (without moving parts) plug-in or battery-operated types. The main-line plug-in energizers, operating from a 110 or 220 volt outlet, are usually more practical since they require no battery maintenance and can energize long lengths of wire. Battery operated units are used where there is no access to plug-in power. Use a 100 amperage, heavy duty industrial (deep-cycling) battery because it is designed to be frequently charged and drained of power. To maintain top efficiency, the battery must be regularly charged or exchanged for a fully charged one. With some high energy units batteries must be recharged or exchanged twice a week.

Solar cells or panels can be used to maintain a peak charge throughout the summer if they are sized appropriately to the energizer. Solar cells are expensive, but work very well and require little maintenance. Specific requirements must be discussed with your dealer to ensure the battery is maintained in peak condition.

If your location is reasonably accessible, consider purchasing a second battery. Rotating two rechargeable batteries on a weekly or bi-weekly basis is a less expensive alternative to using solar cells to maintain the charge in batteries. In this case the energizer must be within easy reach by a vehicle.

An energizer must have a time interval of at least 0.75 seconds between pulses to allow a shocked animal time to relax and pull back from the fence. For this reason, a faulty energizer or the use of more than one energizer on the same wire is extremely dangerous. Do not use two energizers on the same wire.

The energy capability and shocking power of fence energizers are the net effect of voltage and amperage. A combination of electrical pressure (voltage) with which the current is delivered and electrical volume (amperage) is the standard for energizer selection. The product of amperage and voltage is joules (volts x amps = joules). A 9-wire fence with five charged wires around 160 acres of land (16 km of charged wire) with very little vegetative interference requires an energizer of at least 8-10 joules rating.

To be effective, an energizer must produce enough voltage to overcome the insulation resistance of the hair and hide of an animal and still give a sufficient electrical shock. The guard voltage, or voltage produced on a fence, is dependent on the quality of the energizer, the length of wire energized, and the condition of the fence; that is, whether charged wires are insulated, grass touches charged wires, wet conditions, etc.

Guard voltage on a given distance of fence can vary substantially over time, depending on environmental conditions and the condition of the fence. Use an energizer that produces a minimum guard voltage of 4000 volts or more over the length of the fence.

There are many energizers on the market, all varying in quality and performance. Manufacturers rate their energizers according to the length of fence line they will power under ideal conditions. For normal field conditions, divide the manufacturer's figure in half to get the length of wire that the energizer will effectively power. Ensure

that the energizer you purchase will provide adequate voltage over the length of wire to be energized on your fence. Do not try to overextend an energizer.

The Prairie Agricultural Machinery Institute (PAMI) has evaluated many of the electric fence energizers available to farmers. Your regional agricultural engineer or regional supervisor of problem wildlife with Alberta Agriculture can assist you with the selection of the right energizer.

Fence components and their uses

To ensure maximum benefit from an electric fence:

- Select the equipment and material to meet the requirements of the area being fenced.
- Follow proper construction procedures and requirements without taking shortcuts.
- Routinely inspect and maintain the fence properly.

Alberta Agriculture publication *High Tensile Smooth Wire Fencing Manual for Alberta* (Agdex 724-3) explains the materials and procedures used to construct a proper fence and is recommended as a supplement to the following information.

Posts

Although posts of steel, wood or plastic can be used, pressure or dip-treated wooden posts are the most economical and useful for a predator-proof fence. Posts are available in a wide range of diameters and lengths. The number, length and diameter of posts depend on how level and straight the fence will be.

On relatively level terrain in straight areas of the fence, use posts that are 215 cm long and 7.5 to 10.0 cm in diameter, driven 60 cm into the ground. Line post spacing will vary depending on roughness of the terrain, being closer together on undulating land than on level ground. On flat areas, posts can be spaced up to 9 m apart, while in high strain areas, such as over rises or on curves, space them 4 5 m apart. In high strain locations, use longer and thicker posts and drive them in deeper.

Fence wire

Wire suitable for electric fencing must possess the following properties:

- high tensil strength,
- long-term resistance to corrosion,
- low electrical resistance.

Galvanized 12.5 gauge high-tensile smooth wire meets these properties and is also economical (40-50 per cent less in price than double strand barbed wire). Smooth wire is also easier to handle, string and tighten than barbed wire. All wires should be tensioned to 110-135 kg. This keeps the wire straight, parallel and off the ground and provides a more positive electrical contact to an animal simultaneously touching a charged and grounded wire. This wire is also less susceptible to breakage by animals running against it. Although a figure eight knot can be used for attaching ends of high-tensile wire, crimping sleeves provide a stronger splice (figure 4). Galvanizing provides over 35 years of protection against atmospheric corrosion. In general, electricity flows more easily through a larger diameter wire than a smaller wire. Therefore, 12.5 gauge wire will carry an electrical charge a longer distance than thinner gauge wire. For example, 16 gauge wire has 62 per cent higher resistance to the flow of electricity than 12.5 gauge wire.

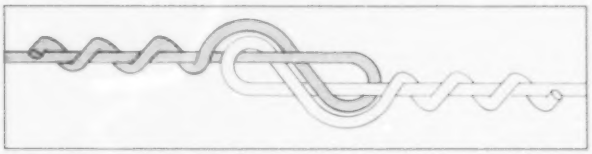


Figure 4a. Figure eight knot.

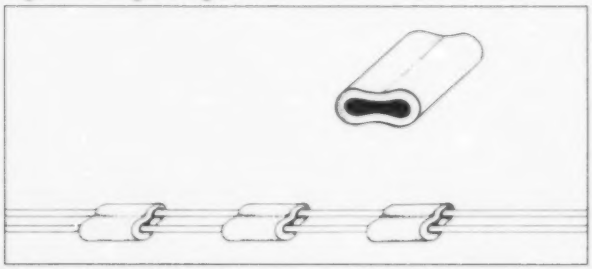


Figure 4b. Methods of joining wire.

Line wire tightener

Each strand of high tensile wire on a fence should have one or more in-line tension adjusters (figure 5). The number of tension adjusters required will depend on how long, flat and straight the fence is. Normally, one in-line tension adjuster is needed per strand for each 400 m of wire. Several models are available at a reasonable cost.

To determine tension on the fence wires, construct a simple homemade device in the following manner (figure 6). Using a board (2.5 x 10 cm) approximately 1100 mm long, place 2 nails (5 cm long) on the centre line of the board and 1016 mm apart. At the mid-point between the nails and 12.7 mm off centre, drive a 17.5 cm nail through the board and into a handle (2.5 x 10 x 40 cm) projecting out from the board at 90 degrees. Leave approximately 2.5 cm of each nail undriven. Place the board under the wire so that the wire is against the two end nails on the board. From the middle of the board use a 10 kg spring scale to deflect the wire until it touches the centre nail. The wire has the proper tension when the

Figure 5a. In-line tension adjuster that requires cutting the wire.

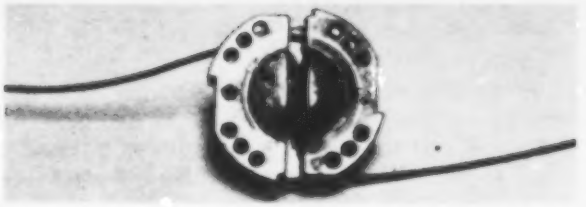


Figure 5b. In-line tension adjuster that does not require cutting the wire.

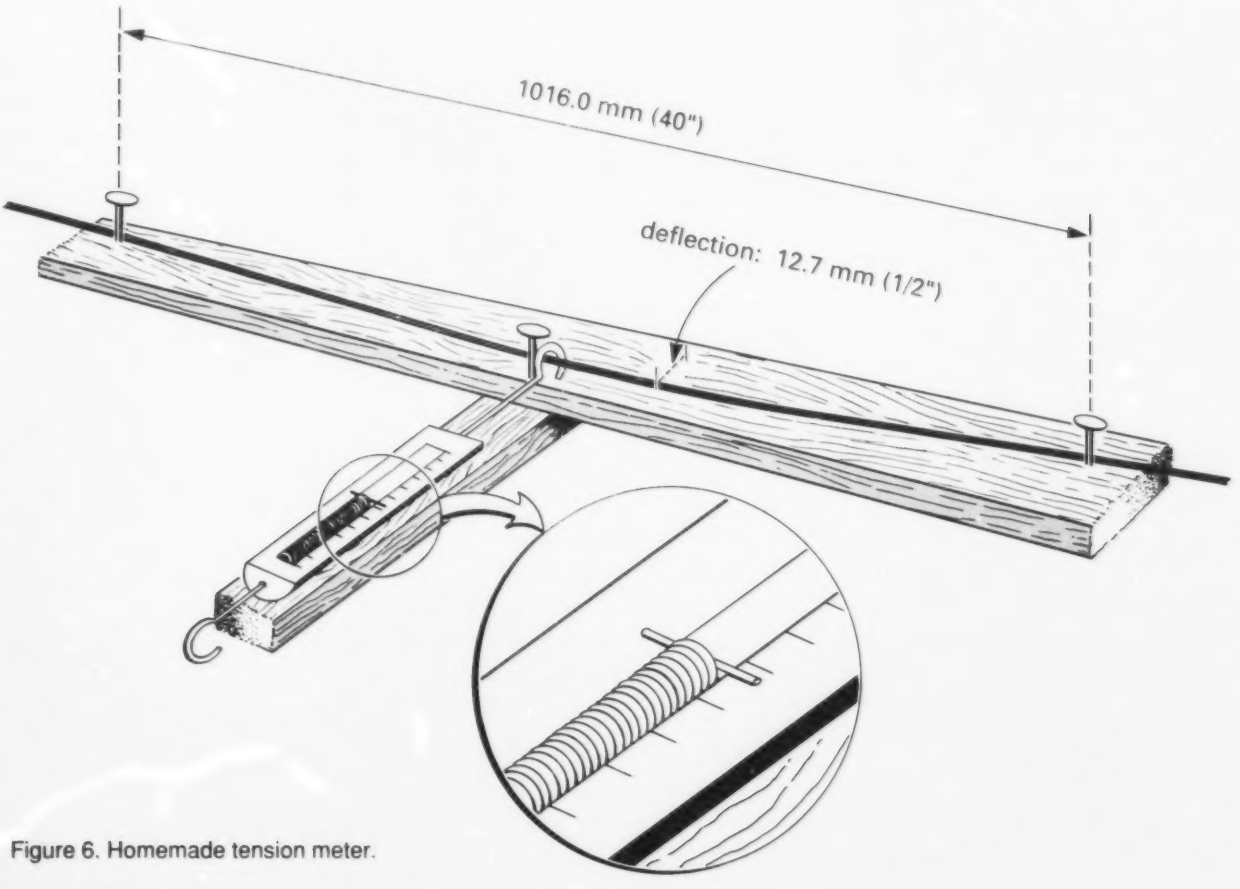
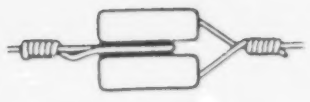
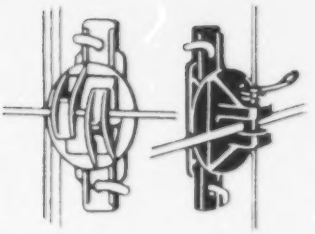


Figure 6. Homemade tension meter.

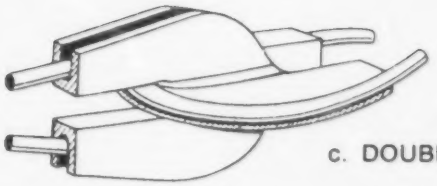


a. PORCELAIN STRAIN INSULATOR



b. LINE POST INSULATORS

d. WRAP-AROUND INSULATOR WITH METAL INSERT



c. DOUBLE "U" INSULATOR

e. PLASTIC TUBE INSULATOR

Figure 7. Types of insulators.

scale measures 5.6-6.6 kg. Since the wire tension will decrease and increase as temperatures increase and decrease respectively, line tightness should be slackened off before winter to prevent possible damage to the wire and fence structure.

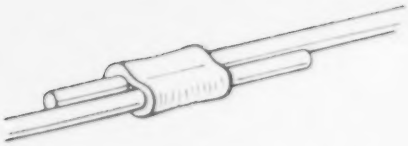
Insulators

Insulators hold the charged wires in place and clear of the fence posts and brace assemblies to prevent electricity leakage to the ground. Insulators are available in different designs (figure 7) and are generally made of plastic or porcelain.

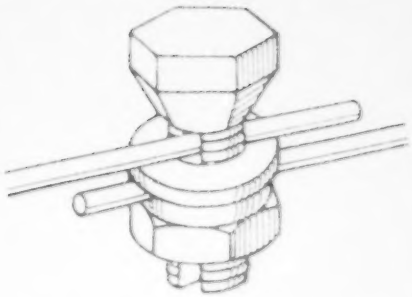
- Porcelain insulators are best suited to high-strain areas such as at corners, gates or on rises and dips of the fence. Porcelain insulators have the disadvantage of being relatively expensive and subject to frost damage and breakage.
- The most common line-post insulators are moulded plastic insulators that are nailed or stapled to the posts. Take care not to drive the nails or staples too deeply so as to distort the insulators.
- Tube insulators are 10 cm long plastic tubes that are slipped onto the wire (one for each post). Fasten these to the post with a staple.
- Wrap-around insulators are designed for wire strung around the outside of posts in corners or curves.
- Rigid, double "U" insulators in porcelain or plastic are for use in insulating tensioned wires at end, corner or gate locations.

Wire connectors

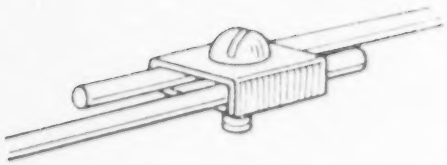
Various methods exist for connecting leadout wires (wire from the charger to the fence) or ground wires onto appropriate wires of the fence (figure 8). For permanently attaching leadout and ground wires onto line wires, or for splicing line wire, use inexpensive compression sleeves. Crimp them at joins using bolt cutters with modified jaws. When using compression sleeves (figure 8a) for attaching ground or live wires to the fenceline wires, make sure that they are threaded onto the fenceline wires and moved to the exact location where they will be fastened before splicing and stapling the fenceline wires onto the posts. Proper line wire splices using compression sleeves are as strong as the existing wire.



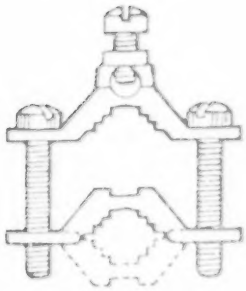
a. COMPRESSION SLEEVE



c. SOLDERLESS CONNECTOR



b. SCREW TYPE LINE CLAMP



d. GROUND ROD CLAMP

Figure 8. Wire connectors and clamps.

Removable screw or solderless galvanized clamps (figures 8b and 8c) can be installed with a screwdriver or small wrench. These provide a quick and easy method to connect leadout or ground wires to line wires already in place on the fence posts. To reduce or prevent corrosion at joins and poor electrical contact, either apply a nondrying sealant, wrap with waterproof electrician's tape or use zinc-enriched "cold-galvanizing" paint.

Ground rods

Use either 20 mm diameter galvanized steel rod or 19 mm diameter galvanized steel pipe in 195 cm lengths as ground rods. Use a minimum of four ground rods driven 185 cm apart, hooked in series and attached to the ground terminal of the energizer (figure 3). Drive additional ground rods at 540 m intervals along the fence. Using a ground rod clamp (figure 8d) attach a 12.5 gauge wire from each rod to the ground return wires of the fence.

Gates

Use conventional wooden or metal gates on an electric fences, but ensure that openings within gates are not larger than 10 cm. Gates should be high enough to discourage predators from jumping over; that is 1.37 m or more in height. The area under gates can be filled flush with gravel or hardpacked soil, or a wooden sill can be constructed to discourage predators from digging.

Live wires and ground wires can be taken above the gate on a crossbar or buried. Going over a gate is cheaper than an underground connection. However, an overhead connection is inconvenient and hazardous when tall equipment is used. Use double insulated cable for the charged wires to cross a gateway below ground level. Connect ground wires with 12.5 gauge high tensile wire. Bury both live and ground wires at least 30 cm deep and encase each in a 12 mm plastic pipe with ends turned down, above ground level to keep out water.

Electrified gates can be purchased, or conventional gates can be electrified with additional hardware.

Lead out wire

Use smooth, high-tensil or insulated 12.5 gauge wire to attach the energizer to the wires being electrified on the fence. The best leadout is two or more wires connected in parallel.

Impedance is the total opposition offered by an electric curcuit to the flow of an alternating current of a single frequency. The difference between the impedance of the leadout wire and the impedance of the fence wire reduces the efficiency of the energizer; the effectiveness of the energizer pulse decreases with distance travelled in the leadout wires. Thus, the leadout wires should be as short as possible.

Grounding the fence

Ineffective shock on a properly wired and energized fence is usually caused by improper or inadequate grounding. To adequately ground an electric fence, drive four 185 cm lengths of ground rod or galvanized pipe (20 mm) into the soil at 185 cm intervals next to the energizer. Place ground rods in a damp location if available. Leave 7.5-15 cm protruding from the soil. Connect a continuous ground wire in series from the energizer to each rod or pipe (figure 3). Use 12.5 gauge high tensile wire for the ground wire and a ground rod clamp on each of the four connections. Drive and connect additional ground rods to all ground-return wires at 540 m intervals along the fence. Do not position ground rods closer than 7.5 m to the following:

- any ground rod connected to another electrical system,
- any telephone ground rod,
- any underground metal pipe system or
- any metal support or other part of a structure sitting on or driven into the ground.

Lightning protection

Most modern electric fence energizers have built in lightning protection. Despite this, energizers can still be damaged by a lightning strike depending on the intensity and location of the strike on the fence. Replacement modules are available for repairing many of the solid-state energizers. A diverter and shock kit are available for a nominal price. This is installed between the power terminal on the energizer and the fence. This mechanism prevents a lightning charge from reaching and damaging the energizer by shunting the charge into the ground. The grounding system of the lightning diverter must be as good or better than the energizer ground system. Since lightning usually strikes the top wire of a fence, proper and sufficient grounding of this and other ground wires of the fence at 540 m intervals will divert most of the charge into the ground.

Volt meter

This is an invaluable and necessary tool to check fence voltage and locate faults in the system. Use a dial-type or digital voltmeter, calibrated in kilovolts (1 kilovolt = 1,000 volts), accurate within 100 volts. To determine the area of electrical leakage on your fence, take readings on the fence at progressive distances from your energizer. A significant drop in voltage indicates the area with the leakage problem.

Vegetation control

Vegetation in contact with charged wires can reduce voltage in the system, particularly during wet weather. Remove the vegetation beneath fence lines, especially in areas where rainfall or foggy conditions are common. Removal of vegetation with herbicides has the advantage of reducing vegetative litter under the fence. Litter can cause inadequate grounding of an animal that touches a charged wire. Use caution when applying herbicides and soil sterilants on hillsides, because erosion could occur.

A strip of vegetation 15 cm on the inside of the fence and 30 cm on the outside of the fence can be controlled with a single treatment of glyphosate at a rate of 2.8 - 4.9 litres/acre of formulated product. Spot treatments might be required annually for persistant weed species.

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